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May 26, 1993

ONR CONTRACT N00014-93-C-0051
PROGRESS REPORT NO. 2 FOR APRIL 16 - MAY 15, 1993
SHIPMENT NUMBER NRD0001AB

Substantial experimental progress has been made, in the second month of the project, in setting up and testing for producing chaotic behavior with a CO_2 laser. The project goal is to synchronize a chaos in CO_2 and other lasers, and thereby increase the power in ensembles of coupled laser sour

Weekly Coordination Meetings of the project team have been held. These meeting have been wel by the project members. Significant technical discussions regarding approaches to the data an theoretical analysis have occured. The successful experimental results described later have provide regarding theoretical considerations. Analysis of the chaotic regime, in detail, is awaiting the n experiments, with additional care to be taken in recording data for subsequent analysis. A second is in the initial stages of assembly. Initial checkout of components indicates a working system sho

TECHNICAL EXPERIMENTAL PROGRESS:

Last month's report described the technical aspects of the project and the progress made towards a l setup to carry out the experimental investigation of nonlinear dynamics of CO_2 lasers. Since then, i new results have been obtained by a simple new technique to induce chaos in CO_2 lasers. In this acoustically modulated feedback of the laser light is used. This new technique, and the results obt described in the following sections.

1. Laboratory Setup

The laboratory experimental setup is shown in Figure 1. The CO_2 laser used consists of a gas glass tube, a plane grating and a ZnSe output coupler. The length of the laser cavity is 2.5 m maximum output power is about 5 W. The output beam of 10.6 micron wavelength from the CC normal to a ceramic surface attached to a diaphram of a radio speaker. The radio speaker is driven by frequency generator capable of driving the speaker in the frequency range of 10 Hz to 100 kHz. T setup is on an optical table that is mounted on air legs to minimize mechanical vibrations. The laser si the grating is detected by a HgCdTe high frequency detector. The output signal of the detector, a amplified, is sent to a spectrum analyzer. The signal is also sent to a scope in XY mode to record t portrait. To obtain the phase portrait, the signal is divided into two parts, and a fixed delay is ir between the two signals.

2. Results

Experimental results are shown in Figures 2 and 3. In these Figures phase portraits, (Inten Intensity($t+\tau$)), are displayed on the right and the corresponding frequency spectra are on the left, fc modulation frequencies. Initially a stable laser output is obtained without any feedback or outside To investigate the influence of acoustically modulated feedback, oscillations are turned on, in the attached to an audio speaker, at a frequency of 51.4 kHz (Fig 2a). The frequency spectrum in l shows a second harmonic at 102.2 kHz in addition to the peak at the modulation frequency (51.4 kl indicates that acoustically modulated optical feedback produces periodic oscillations in laser outpu not seen from a stationary reflecting surface.

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ONR CONTRACT N00014-93-C-0051
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Various frequencies were used to investigate the effect of modulation frequency on the induced and the induced instabilities in the laser output. These effects are illustrated in Figures 2c and 3 frequency of modulation is varied, (in this case decreased) the laser output becomes more and more This is shown in Figure 2c where five harmonics are observed in addition to the modulation freque kHz. The related phase portrait changes are shown in Figures 2b and 2d.

As the modulation frequency approaches about 7 kHz, the frequency spectrum of the laser outp as shown in Figure 3a, indicating the presence of a higher period orbit accompanied with subhar the modulation frequency is further decreased to 375 Hz, the signal intensity suddenly shows large f and the frequency spectrum (Figure 3c) becomes broadband with about 30 db rise in the floor level. strongly indicates that the system is driven into a chaotic regime. The corresponding phase portra a strange attractor (Fig. 3d) at this modulation frequency of 375 Hz.

SUMMARY:

* A new technique has been developed to create instabilities and chaos in CO_2 gas l
* This new technique involves acoustically modulated feedback of the laser light.
* A complicated sequence of interlocking periodic and chaotic regimes in the freque of 1 kHz to 100 Hz has been observed and recorded.
* Preparations are moving forward to control some of these chaotic regimes.
* A second CO_2 laser is being assembled.

END

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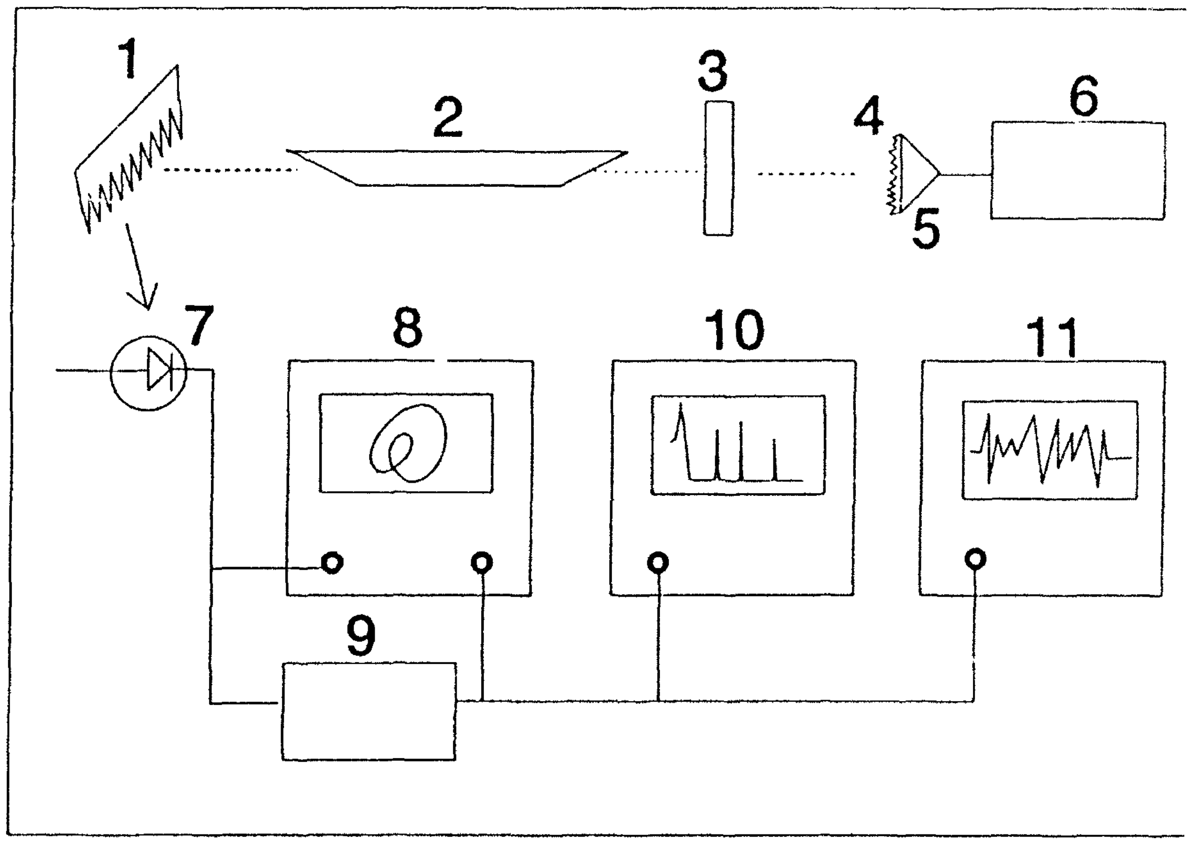


Figure 1: Experimental set up: 1. grating 2. CO_2 laser tube 3. output mirror 4. cerai 5. radio speaker 6. frequency generator 7. LN_2 cooled HgCdTe detector 8. oscillosc 9. delay line 10. spectrum analyzer 11. oscilloscope

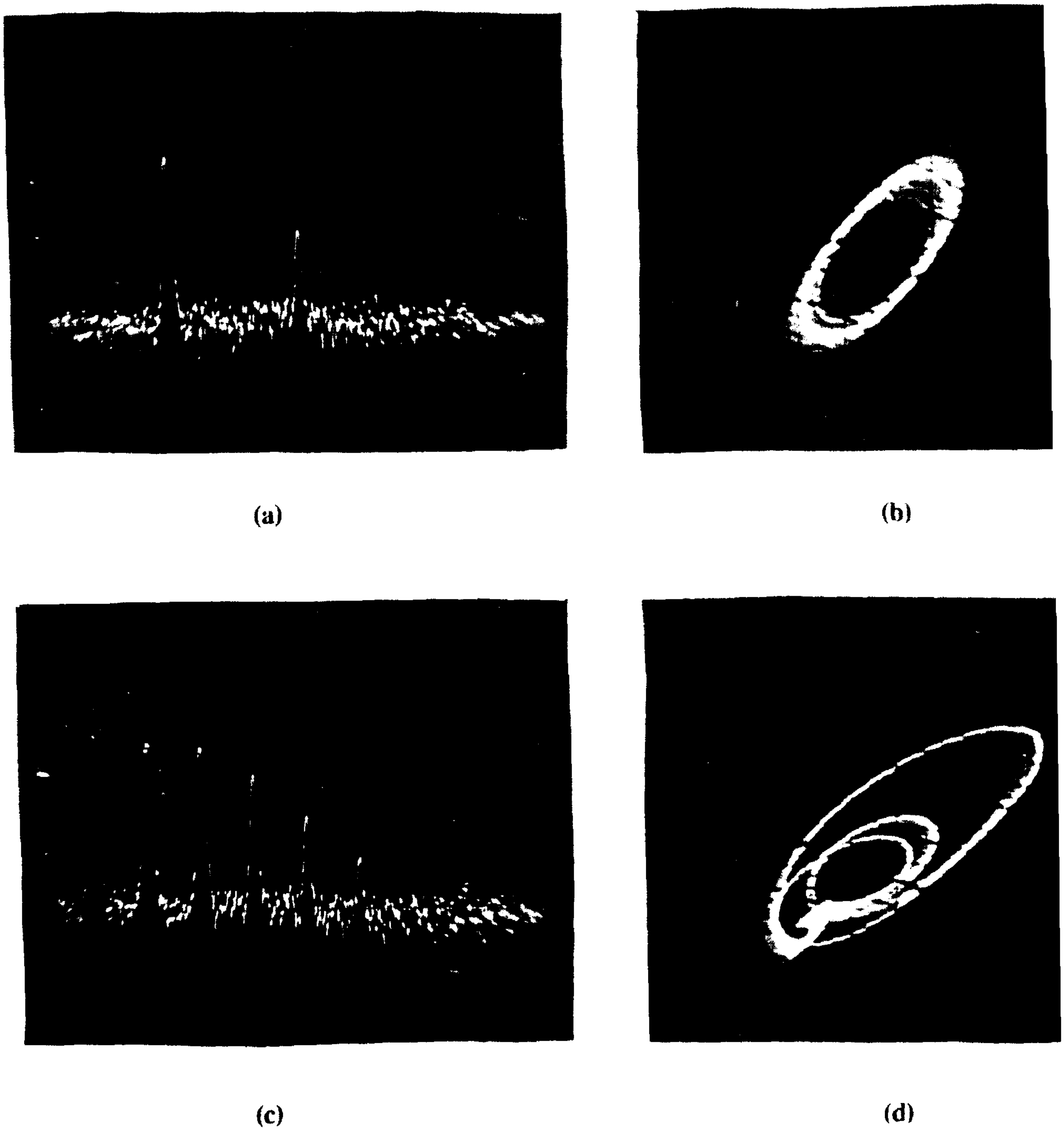
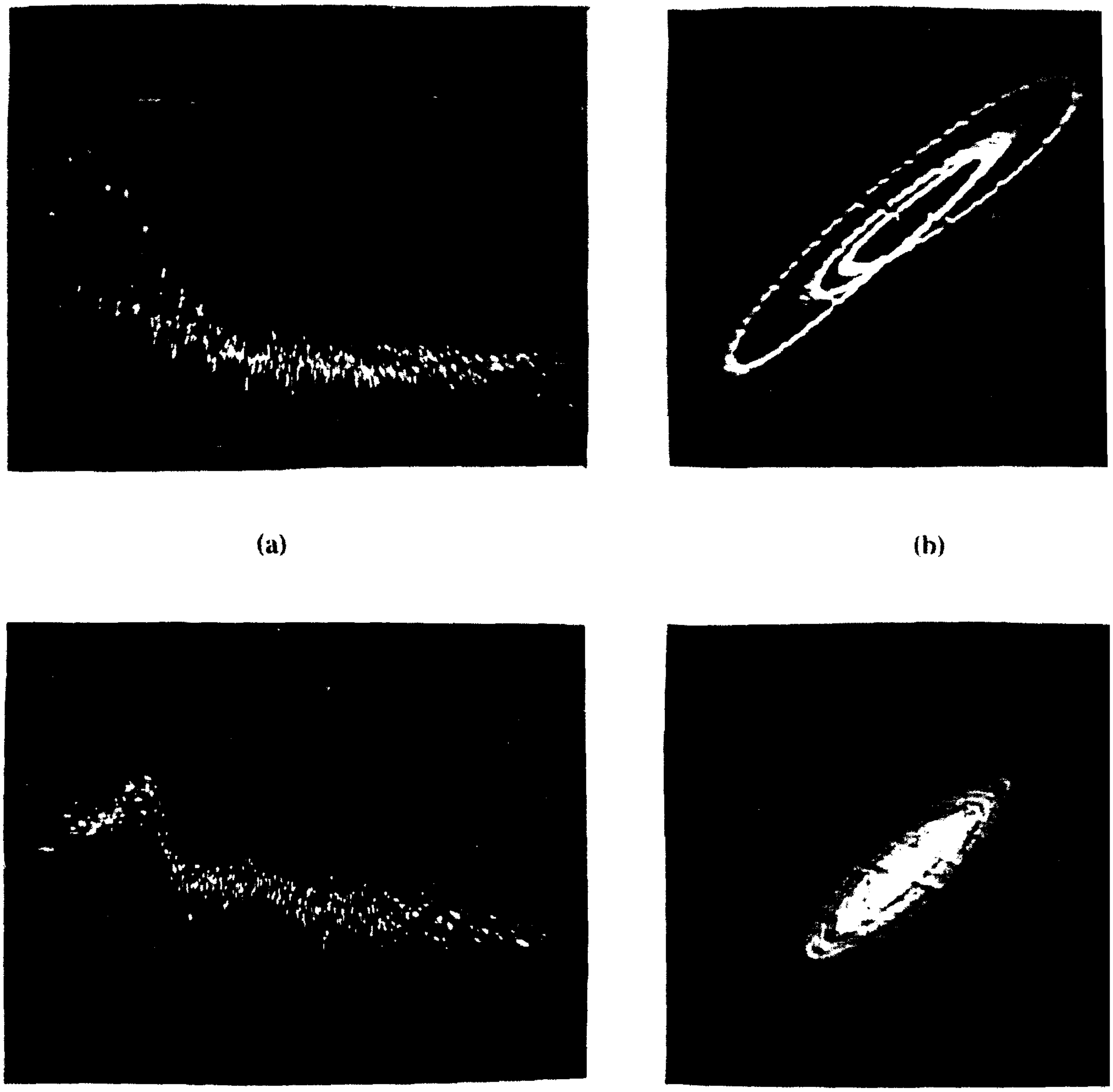


Figure 2: Frequency Spectra (a) and (c) with corresponding Phase Portraits (b) and (



(a) (b)

(c) (d)

Figure 3: Frequency Spectra (a) and (c) with corresponding Phase Portraits (b) and (d